ISSN 1068-7998, Russian Aeronautics (Iz.VUZ), 2018, Vol. 61, No. 1, pp. 8–13. © Allerton Press, Inc., 2018.
Original Russian Text © T.Yu. Gainutdinova, V.G. Gainutdinov, 2018, published in Izvestiya Vysshikh Uchebnykh Zavedenii, Aviatsionnaya Tekhnika, 2018, No. 1, pp. 11–16.

FLIGHT VEHICLE DESIGN

Design and Experimental Analysis of Aircrew Design Parameters to Vertical Takeoff and Landing

T. Yu. Gainutdinova[a, *] and V. G. Gainutdinov[b]

[a]*Kazan (Volga region) Federal University, ul. Kremlevskaya 18, Kazan, 420008 Tatarstan, Russia*

[b]*Tupolev Kazan National Research Technical University, ul. Karla Marksa 10, Kazan, 420111 Tatarstan, Russia*

**e-mail: tgainut@mail.ru*

Received December 6, 2016

Abstract—The calculation of the design parameters of lifting airscrew systems with fixed and tilted rotor, including the investigation of the operation schemes of actuators for the propeller control system, is carried out.

DOI: 10.3103/S1068799818010026

Keywords: unmanned VTOL aircraft, lifting airscrew.

INTRODUCTION

For the period of 2015–2016, several types of vertical takeoff and landing (VTOL) aircraft with a takeoff weight of 6 and 70 kg (convertible), 120 and 150 kg (copter-type), and 180 kg (with a combined power plant) were designed and put to test flight. The main task that should be solved is stable vertical takeoff and landing providing for a VTOL aircraft with fixed and tilted rotors. The goal can be attained in several steps that include the takeoff simulation and adjustment of the PID-regulator coefficients by using special test benches and plane hanging, and finally by test flights. This way of design and tests reduces a damage risk for experimental prototypes.

For simulation, we developed a software package that comprises of:

—software for calculating the airscrew blade design geometry (blade chord and twist angles) that provides the maximum thrust for available engine power or minimum required power at the given thrust for specified axial flow velocities. Software is used in design of fixed and variable pitch takeoff and cruise airscrews;

—software for preliminary performance calculation of unmanned aerial vehicles (UAV) of aircraft type. It is used for automatic flight track update that is preset on a ground station by checking the realizability of programmed maneuvers (accelerated and decelerated flight duration and distance, turn radius etc.);

—software for calculating the initial alignment on determining the UAV start attitude (both the constant components of the angle rate sensor data drift and the starting direction cosine matrix (DCM) are calculated);

—software of simulating the UAV copter and aircraft flight modes using the experimental (or calculated) values of the aerodynamic force and moment factors and the data on thrust T and power P of take-off and cruise engines versus the flight velocity.

We use time integration for the known equations of translational and rotary motion. The most convenient for the aircraft flight mode are the translational motion equations used relative to the longitudinal acceleration $\dot{V}$ and the time derivatives of the attack and slip angles $\dot{\alpha}$ and $\dot{\beta}$ [1, 2].

Software for simulating the UAV initial alignment and flight is used for onboard program debugging. The calculated values that simulate the accelerometer, gyroscope, and magnetometer data are put into